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(56) Documents cited
GB 1420813 A GB 0729351 A GB 0680444 A
GB 0573636 A GB 0534171 A GB 0521185 A
GB 0512624 A GB 0324206 A

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(54) **A bearing material**

(57) A Cu system bearing material comprises a backing material e.g. a steel strip, a layer formed on the backing material by sintering metal or alloy particles, and a bearing layer formed on the sintering alloy layer. The alloy contains 14 to 20% by weight Pb and 4 to 40% by weight Sn, the remainder being Cu.

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Fig.1

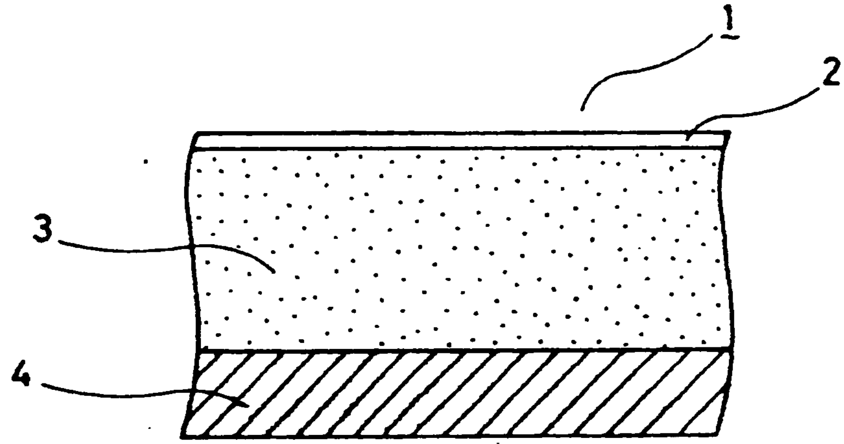


Fig.2

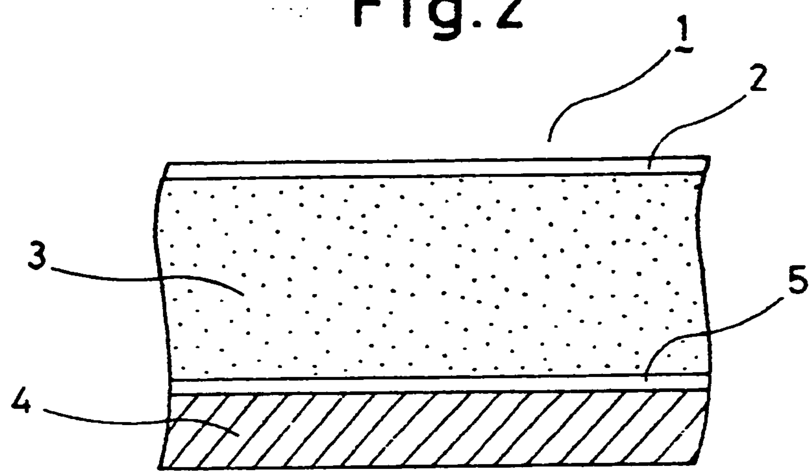


Fig.3

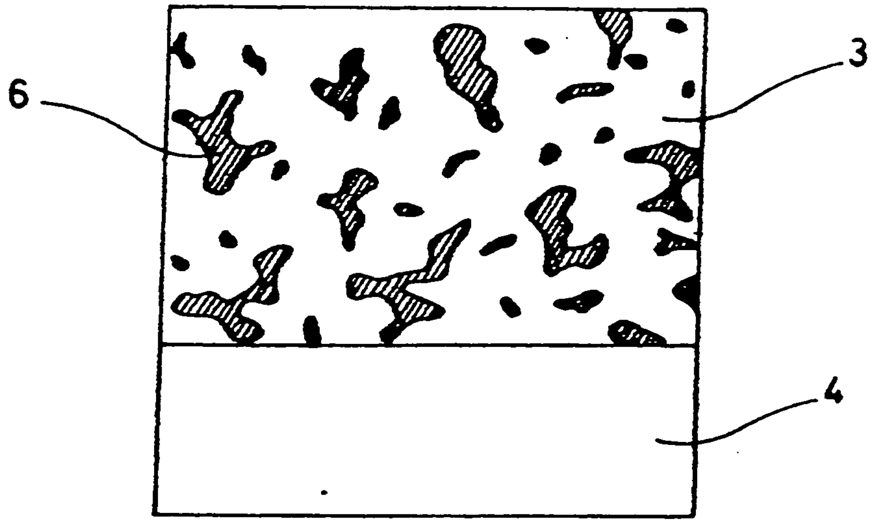


Fig.4

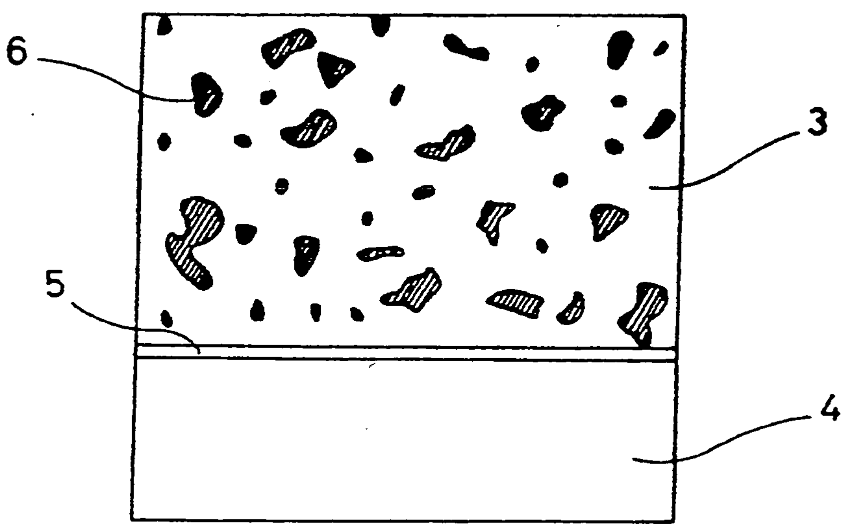
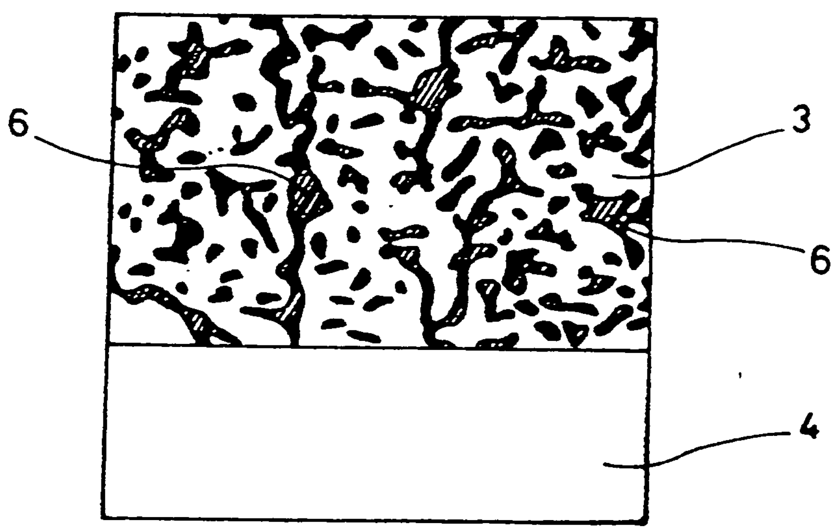


Fig.5



A BEARING MATERIAL

Bearings are used to support journalled and frictional parts of internal combustion engines and compressors in vehicles and ships. The bearing material should have fatigue strength, load-resistance, friction-resistance and wear-resistance.

In a conventional bearing material, a bearing layer, supporting a journal or the like, is formed on a strip of soft steel or other backing material, and one or more intermediate layers are provided between the bearing layer and the backing material. The intermediate layers are formed either by casting or sintering; they consist of copper or a copper alloy (hereinafter referred to as a Cu system) or of aluminium or an aluminium alloy (hereinafter referred to as an Al system). Bearing materials which include an Al system bearing layer (hereinafter referred to as Al system bearing materials) are lighter in weight than and economically preferable to those including Cu system bearing and/or intermediate layers (hereinafter referred to as Cu system bearing materials), and are extensively used for journal bearings of automotive internal combustion engines. Recently, however, there have been demands for size reduction and increased output of such engines, and, particularly, the use of exhaust gas purifiers to cope with pollution problems. Therefore, the bearing materials are more frequently used under higher load, at higher frictional speeds and at higher temperature. For this reason, Cu system bearing materials have again been used, in lieu of Al system bearing materials.

Cu system bearing materials have been based on bronze-type alloys which contain up to about 30% Sn. If the Sn content is up to about 14%, the alloy is in the form of an α-solid solution, and the matrix is generally in the form of α+α crystals. Owing to this structure,

such bronze alloys have good strength and wear-resistance.

In addition to these properties, however, the bearing material should have good frictional characteristics. Therefore, 20 to 30% Pb is usually added in addition to Sn. However, Pb and Cu can form a solid solution over a very slight range only, and practically they will not form any solid solution. Therefore, the added Pb is precipitated in the bronze alloy matrix. The precipitated particles of Pb may also unite, to form continuous bodies. Under repeated external loads, such a Cu system bearing material is liable to break along the continuous bodies. In addition, it is liable to be corroded by lubricant.

Sn- and Pb-containing Cu system bearing materials have been proposed, with the intention of overcoming the drawbacks caused by the addition of Pb. For example, US-A-0180008 discloses a bearing material, in which a multi-layer structure of copper alloy consisting of intermediate and bearing layers is formed on a backing material of soft steel. The multi-layer structure is formed by casting. The surface bearing layer is of a lead alloy containing 2 to 10% In and selectively 0.1 to 3% Cu, 0.001 to 0.25% Te, 0.5% or less Ag and/or 0.5% or less Sb, the remainder being Pb; the intermediate layer is a copper alloy layer containing 5 to 35% Pb and 20% or less Sb, the remainder being Cu. In in the surface bearing layer partly enters the intermediate layer, to form a Cu-In alloy, thus improving the anti-abrasion properties, while being also partly coupled to Pb, to improve the frictional property. Further, if the intermediate layer is exposed partly or totally, due to breakage of the bearing layer, the intermediate layer exhibits a bearing function, for it has a bronze alloy structure and contains precipitated Pb as a lubricant

component. However, in forming the multi-layer structure, the backing material is bent into a channel shape and then heated in, for instance, a reducing atmosphere at about 1100°C, a molten copper alloy is cast as the intermediate layer on the backing material, the system is quenched, molten lead alloy is cast as the surface layer, the system is again quenched, and then the opposite edges of the backing material are cut apart. The processing of the backing material, and repeated casting and quenching, are cumbersome, and the yield is low. Further, the bearing layer of the half bearing, which is formed by working the bearing material, contains a comparatively large amount of expensive In (in addition to Pb).

US-A-4406857, GB-A-0658335 and JP-A-94501/1982 disclose Cu system bearing materials, in which the bearing and intermediate layers are formed by sintering.

In the bearing material disclosed in US-A-4406857, a sintered alloy layer containing 8 to 27% Pb, 0.5 to 10% Sn and 2 to 10% Ni, the remainder being Cu, is formed as bearing layer or intermediate layer on a backing material consisting of a steel sheet strip. The matrix of the sintered alloy layer has a bronze structure, in which Cu and Sn form a solid solution, and Pb is dispersed in the matrix. However, the structure is not a cast structure but a sintered structure. Therefore, adhesion between the alloy layer and backing material is poor, and Pb is liable to form continuous bodies. By adding 2 to 10% Ni, the Pb continuous bodies are avoided, while Ni forms a solid solution in the matrix, thus improving the mechanical strength, but this solution is very expensive. In addition, the fatigue strength is not much improved.

GB-A-0658335 discloses a Cu alloy layer formed as a sintered layer on a backing material. A portion of the sintered alloy layer close to the backing material has as

much as 4 to 11% Sn, while a portion forming the bearing surface has a little as 1.5%, or less, Sn. Sn close to the backing material provides good adhesion between the alloy layer and backing material, but it is cumbersome to vary the Sn content in the thickness direction of the sintered alloy layer. In addition, Pb continuous bodies are formed.

The Cu bearing material disclosed in JP-A-94501/1982 contains a sintered alloy layer containing up to 5% by weight Ni and up to 3% by weight Sb as well as up to 20% by weight Pb and 4 to 10% by weight Sn, the remainder being Cu. The Sb avoids continuous bodies of Pb, but both Ni and Sb are very expensive and have to be added in comparatively large amounts if a satisfactory yield is to be obtained.

A bearing material according to the present invention comprises a sintered alloy layer, formed by sintering metal or alloy particles on a steel strip backing material, and usually also a bearing layer on the sintered alloy layer. The alloy contains 14 to 20% by weight Pb and 4 to 10% by weight Sn, the remainder being Cu.

The alloy is inexpensive, since it does not contain any elements other than Sn and Pb. The large amount of Sn promotes bronzification and has the effect of reinforcing the matrix. It is thus possible to enhance the friction-resistance, fatigue strength and corrosion-resistance property, thus improving the bearing performance. Further, since Pb is incorporated in a comparatively small amount, Pb particles are well dispersed, so that it is possible to enhance the lubricative property without adversely affecting the fatigue strength. Even if the bearing layer is formed as a plating alloy layer, sufficient lubrication property can be maintained as well as initial affinity.

A layer consisting solely of Cu may be formed on the surface of the backing material. Cu in such a cover layer and a Cu-Sn alloy matrix in the sintered layer are sufficiently dispersed to enhance the adhesion between the backing material and the sintered alloy layer.

The alloy should be sintered at a temperature below that of prior sintering processes, to prevent the formation of large Pb particle precipitates; fine Pb particles can be obtained in the matrix.

The present invention is based on the following considerations:

(a) Where a bearing layer of a plated metal or alloy is formed on a sintered alloy layer, the initial affinity is provided by this surface bearing layer. Where the life of the bearing layer itself can be maintained not only initially but for a long time, sufficient bearing performance should be maintained owing to the present of the bearing layer.

(b) If the bearing layer can be maintained by the sintered alloy layer, the latter provides enhanced bearing performance in cooperation with the surface bearing layer. It should then be possible to enhance the hardness of the sintered alloy layer, while the bearing layer is firmly held by the sintered alloy layer.

(c) Satisfactory bearing performance of the bearing material cannot be attained by merely enhancing the lubrication property by adding Pb and other lubricating components, but only when such properties as hardness, wear-resistance, fatigue strength, load-resistance and lubrication property are considered together.

(d) It is not cost-effective to incorporate Ni and Sb in large amounts.

The invention will now be described by way of example only with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view of a bearing material according to the invention;

Fig. 2 is a sectional view of another bearing material;

Figs. 3 and 4 are views of the structures of part of the bearing materials shown respectively in Figs. 1 and 2; and

Fig. 5 is a view of the structure of a sintered alloy in a prior art bearing material.

Fig. 1 shows a bearing material 1 embodying the invention, which comprises a surface bearing layer 2, an intermediate sintered alloy layer 3 and a backing material 4. The bearing layer 2 is a very thin plating alloy layer containing Pb and/or Sn. The sintered alloy layer 3 is formed integrally on the backing material 4 by sintering metal or alloy particles, and it contains 14 to 20% Pb and 4 to 10% Sn, the remainder being Cu. Although Pb, Sn and Cu may be incorporated as the respective elements, they may also be incorporated as the alloy particles, for instance as Cu-Sn alloy particles. Such particles are sprayed on the steel strip backing material and sintered under pressure in a reducing atmosphere at a temperature of 750 to 800°C.

Sn forms a solid solution with Cu to form a bronze structure. This bronze structure has the effect of improving mechanical strength and improving corrosion-resistance. From these standpoints alone, as much Sn as possible is used, but too much Sn means that no solution is formed, but rather phases. In order to meet the recent demand for increased output of internal combustion engines, the large amount of Sn which is used, compared to the prior art, gives a solid solution with Cu, thus increasing mechanical strength, tensile strength and shearing strength, as well as improving corrosion-resistance.

Pb is added in a range of 14 to 20%. Preferably, as much Pb as possible is used, in order to improve the lubrication and seizure-resistant properties, and to provide satisfactory bearing properties. By way of example, the SAE Standards 48, 794 and 799 prescribe that the bearing material should contain as much Pb as 21 to 32%. However, where such a large amount of Pb is incorporated, matrices are destroyed causing loss of fatigue strength. If the Pb content is too low, the possibility of seizure is present.

The use of Sn in an amount of 4 to 10% can improve the hardness of matrices, by bronzification, to about HRT 15 T 80 above a prior art example value of HRT 15 T 60. Thus, even if the surface bearing layer is a thin plating layer, it is held firmly and soundly by the sintered alloy layer, so that enhanced bearing performance can be obtained.

If the content of Pb in the sintered alloy layer is reduced to 14 to 20% at the same time, it is possible to maintain a lubrication property which is comparable to that when a greater amount, 21 to 32% Pb, is added, owing to the fact that the surface plating, as a bearing layer, has a long life. Substantially no difference can in fact be recognised in the threshold seizure load in friction/wear tests.

The Pb is precipitated as a dispersion, and does not form continuous bodies in the matrices, as long as it is incorporated in a range of 14 to 20%, preferably 14 to 18%, and no other additive component is incorporated. Therefore, problems are minimised in the event of exposure of the surface of the sintered alloy layer due to occasional wear or breakage of the surface bearing layer. Thus, the fatigue strength of the sintered alloy layer is increased, and the bearing layer

can be held firmly and soundly even if it experiences externally-applied shock.

To improve the bearing performance, it is desirable to enhance the adhesion between the sintered alloy layer and the backing material 4 in addition to reinforcing the sintered alloy layer 3. The adhesion is suitably enhanced by forming a cover layer 5 comprising substantially only Cu, by plating on the surface of the backing material 4, as shown in Fig. 2.

The following Examples 1, 2 and 4 illustrate the invention.

Example 1

The surface of a soft steel strip was cleaned. Metal and alloy particles containing 18% Pb and 5% Sn, the remainder being Cu, were sprayed on the cleaned surface and heated at 750 to 800°C, in a reducing atmosphere, to obtain a sintered layer on and integral with the backing material. The sintered layer was then compressed, using a roller, to increase its density. A Pb-Sn layer was then plated on the sintered alloy layer. Fig. 3 is an enlarged representation of a photograph of a section of part of the resultant bearing material.

Example 2

A layer, 3 μm thick, comprising substantially only Cu, was plated on a soft steel strip. A sintered alloy layer having the same composition as that in Example 1 was formed thereon, by heating in a reducing atmosphere, at 700 to 750°C, i.e. at a temperature 50°C lower than the temperature in Example 1. A Pb-Sn layer could then be provided on the resultant bearing material, as in Example 1. Fig. 4 is an enlarged representation of a photograph of a section of part of the resultant bearing material.

Example 3 (comparative)

A sintered alloy layer, containing 25% Pb and 1.5%

Sn, the remainder being Cu, was formed on a steel strip. Fig. 5 is an enlarged-scale photograph of a section of the bearing material.

Plain split bearings were fabricated using the bearing materials of Examples 1 to 3. Durability tests were conducted, using an Underwood tester, under specified conditions (bearing surface pressure: 700 kg/cm^2; oil clearance: 30 to 50 µm; rate of rotation of shaft: 3500 rpm; material of shaft: S 45 C; lubricant: SAE 20W - 40). The time to metal fatigue, and proportion of test pieces in which the metal fatigue occurred, were recorded.

The proportion of satisfactory pieces is tabulated below. By way of example, when the proportion is 80%, metal fatigue occurred in 20% of all the test pieces in given time.

	% Proportion of satisfactory pieces									
Time (h)	20	40	60	80	100	120	140	160	180	200
Ex. 1	100	100	100	100	80	80	80	80	80	60
Ex. 2	100	100	100	100	100	80	80	80	80	70
Ex. 3	86	86	86	86	86	75	58	50	40	40

The test pieces in which metal fatigue occurred were examined. It was found that fatigue fissures first occurred on the surface, and developed to reach the back surface in close proximity to the backing material. Where precipitated Pb particles 6 were continuous or closely spaced, as shown in Fig. 5, fissures were produced in the matrix along Pb particles 6, and these fissures caused separation of the sintered alloy layer from the backing material or separation of the bearing

layer formed by plating as described later. For the bearing materials according to the invention, in contrast, Pb particles 6 are dispersed.

Example 4

A 10% Sn - 3% Cu - 87% Pb alloy was used to form a bearing layer 15-30 μm thick on the surface of test pieces prepared in accordance with Examples 1 to 3. Split bearings were fabricated from the resultant bearing materials and subjected to a durability test under the same conditions as above. Unless metal fatigue occurred in the sintered alloy layer, the lubrication property of the bearing layer was satisfactory. In spite of the occurrence of partial wear on the bearing layer, there was no fatigue on the sintered alloy layer. Therefore, good lubrication could be maintained, and an endurance period longer than that of Example 1 can be obtained.

CLAIMS

1. A bearing material comprising a backing and an alloy layer formed by sintering, in which the alloy contains 14 to 20% by weight Pb and 4 to 10% by weight Sn, the remainder being Cu.

2. A bearing material according to claim 1, which additionally comprises a bearing layer on the alloy layer.

3. A bearing material according to claim 2, wherein the bearing layer is a plating layer of an alloy containing lead and/or tin.

4. A bearing material according to any preceding claim, which further comprises a copper layer serving to bond the backing material and the alloy layer.

5. A bearing material according to any preceding claim, wherein the backing material is steel.

6. A bearing material according to claim 1, substantially as described in any of Examples 1, 2 and 4.

Amendments to the claims have been filed as follows

1. A bearing material comprising a steel backing; an intermediate alloy layer formed by sintering, in which the alloy contains 14 to 20% by weight Pb and 4 to 10% by weight Sn, the remainder being Cu; and a plating layer of an alloy containing Pb and/or Sn.

2. A bearing material according to claim 1, which additionally comprises a copper layer serving to bond the backing material and the alloy layer.

3. A bearing material according to claim 1 or claim 2, which is free of lubricating oil.

4. A bearing material according to claim 1, substantially as described in any of Examples 1, 2 and 4.

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